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ABHANDLUNGEN

Socio-Environmental Crises and Cognitive Ageing. Exploring the Cognitive Impact of the COVID-19 Pandemic and Climate Crises on Older Adults' Memory and Verbal Fluency

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Abstract Socio-environmental crises such as the ones induced by the COVID-19 pandemic and ongoing climate change significantly impact individual health, not only but especially at older ages. While the health effects of COVID-19 lockdowns and the cardiovascular risks posed by climate change (especially heat waves) in the older population have been studied, their differential impacts on cognitive functioning in later life remain less understood, despite their relevance for the sociology of age(ing). This article thus explores the "cognitive impact" of socio-environmental crises by addressing two questions: (1) How does cognitive functioning change from the prepandemic to the postlockdown phase, and how does this compare with baseline cognitive changes? (2) How are average and peak summer temperatures linked to cognitive change over a 2-year period?

Using longitudinal data from the Survey of Health, Ageing and Retirement in Europe (SHARE), we analysed cognitive changes in a sample of adults aged 50+ in Germany from 2004 to 2022. Random effects change score analysis focused on two cognitive measures: memory and verbal fluency. Results show that COVID-19–related cognitive decline in memory is significantly greater than baseline change rates of cognitive decline, but no such effect was observed for verbal fluency. Higher average summer temperatures are associated with faster declines in memory and verbal fluency, while peak summer temperatures are not correlated with cognitive

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Online Appendix: www.kzfss.uni-koeln.de/sites/kzfss/pdf/Bertogg-Brandt.pdf

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functioning. While the social and biological mechanisms behind such changes still need to be disentangled scientifically, the sociopolitical need for action during times of polycrises is unquestionable.

Keywords Cognitive health · Later life · Heat waves · Viral epidemic · Public health

Sozial-ökologische Krisen und kognitives Altern. Eine Untersuchung der kognitiven Einflüsse der COVID-19-Pandemie und der Klimakrise auf Gedächtnisfunktion und verbale Funktion älterer Personen

Zusammenfassung Sozial-ökologische Krisen, wie sie durch die COVID-19-Pandemie sowie den fortschreitenden Klimawandel hervorgerufen werden, haben signifikante Auswirkungen auf die individuelle Gesundheit – nicht ausschließlich, aber insbesondere im höheren Lebensalter. Während die gesundheitlichen Folgen pandemiebedingter Lockdowns sowie die kardiovaskulären Risiken klimatischer Extremereignisse (insbesondere Hitzewellen) für ältere Bevölkerungsgruppen bereits empirisch untersucht wurden, ist über ihre differentiellen Effekte auf die kognitive Leistungsfähigkeit im höheren Lebensalter bislang wenig bekannt – obwohl diese für eine Soziologie des Alterns von zentraler Relevanz sind. Der Beitrag untersucht daher den „kognitiven Einfluss“ sozial-ökologischer Krisen und adressiert zwei Fragestellungen: (1) In welcher Weise verändert sich die kognitive Leistungsfähigkeit von der präpandemischen zur post-lockdown-Phase – und wie sind diese Veränderungen im Vergleich zu altersnormativen kognitiven Verläufen einzuordnen? (2) In welchem Zusammenhang stehen durchschnittliche oder maximale Sommertemperaturen mit kognitiven Veränderungen über einen Zeitraum von zwei Jahren?

Anhand von Längsschnittdaten des Survey of Health, Ageing and Retirement in Europe (SHARE) werden kognitive Veränderungen bei in Deutschland lebenden Personen ab 50 Jahren im Zeitraum von 2004 bis 2022 untersucht. Um Change Scores in zwei kognitiven Indikatoren, Gedächtnisleistung und verbaler Funktion, zu untersuchen, werden Random-Effects-Modelle verwendet. Die Ergebnisse zeigen, dass pandemiebedingte kognitive Einbußen in Gedächtnisleistung signifikant über alterstypische Veränderungen in einem Zeitraum von zwei Jahren hinausgehen, während für verbale Funktion kein vergleichbarer Effekt nachweisbar ist. Höhere durchschnittliche Sommertemperaturen sind mit beschleunigten Einbußen in beiden kognitiven Bereichen assoziiert, während Maximaltemperaturen nicht mit kognitiven Veränderungen korrelieren. Auch wenn die sozialen und biologischen Wirkmechanismen hinter diesen Befunden noch zu ergründen sind, ist die gesellschaftspolitische Handlungsnotwendigkeit im Kontext multipler Krisen deutlich.

Keywords Kognitive Gesundheit · Altern · Hitzewellen · Virus-Epidemie · Public Health

1 Introduction

Social–environmental crises impact individual health and well-being in manifold and socially stratified ways (Abedi et al. 2021; Barrett and O' Sullivan 2013; Marazziti et al. 2021; Newnham et al. 2022; Wachtler et al. 2020). In doing so, they pose fundamental challenges for societies and policies, yielding the risk of widening social inequalities in healthy ageing, participation, and well-being in later life.

Whereas the severe health crisis due to the recent COVID-19 pandemic has been studied extensively (e.g. Sepúlveda-Loyola et al. 2020; Tur-Sinai et al. 2022), research is only starting to assess the impacts of climate change on health, well-being, and mortality (e.g. Ebi and Hess 2020; Martinez et al. 2011). Most studies on older populations up to now have dealt with the later life consequences of extreme temperatures (Brandt and Höppner 2024), such as the recent 2022 summer heat in Europe, which has been estimated to have resulted in 60,000 premature deaths (The Lancet Public Health 2024).

Even though developments are likely aggravated in other parts of the world (with more extreme natural and weather conditions, lower health [policy] standards, and higher social inequalities), rising summer temperatures, pollution, draughts, storms, and floodings have taken their toll on the physical and mental health of the German (ageing) population, too, as was shown by the German health monitoring as part of the Status Report on Climate Change and Health 2023 (*Sachstandsbericht Klimawandel und Gesundheit 2023*; Winklmayer et al. 2023). For instance, significant heat-related mortality especially affecting the older population was recorded for the first time for three years in a row (2018 to 2020; Winklmayer et al. 2023, p. 10). Although the study of environmental health risks in Germany has a long tradition (Bolte et al. 2023; Heinrich et al. 2000), climate-related risks to cognitive health in later life are less well understood. Similarly, although the physical and mental health risks of the COVID-19 pandemic for the German population (Bäuerle et al. 2020; Neumann et al. 2025; Wettstein et al. 2022, 2023), especially older adults, have been well studied, evidence is lacking regarding the cognitive impact of such a crisis. Despite the obvious relevance of both climate impacts on cognitive reserves for the sociology of age(ing) (Brandt and Höppner 2024), we thus still know little about the socio-environmental risks on cognitive ageing.

Cognitive ageing, which is the gradual decline in cognitive functioning with age, is a "normal" feature of ageing, and its speed is critical for developing cognitive impairments and eventually passing the threshold to diagnosed dementia (Albert et al. 2011; Livingston et al. 2017; Stern 2002). Moreover, cognitive abilities are essential for participation in both the labour market, particularly in later career stages (Karcz et al. 2022), and society, including living independently (Górska et al. 2022; Li et al. 2022a; Lindquist et al. 2022). In light of lacking a universal, accessible, and affordable cure for individuals affected by various types of dementia, prevention remains the key lynchpin to reduce the economic, political, and social costs of this epidemiological challenge (Livingston et al. 2017, 2020).

Yet the sociological study of these preventive factors is still an emerging field (Bertogg and Leist 2023), and in times of "poly-crisis" (Lawrence et al. 2024), it is of high relevance for public health and social security systems. Dementia-related conditions are among the seven leading causes of death worldwide and are growing rapidly in lower- and middle-income countries (Kenne Malaha et al. 2023; Prince et al. 2008). Exploring the cognitive impacts of socio-environmental crises (COVID-19, heat waves) not only offers globally transferrable insights but also opens opportunities for understanding mechanisms and prevention potentials for a growing societal concern, not exclusively but especially from a sociological point of view.

1.1 Research Questions and Contributions

In this study, we investigated the impact of two socio-environmental crises on cognitive ageing—COVID-19 and summer temperatures—addressing the following research questions:

1. How did cognitive functioning change from the prepandemic to the postlockdown phase, and how does this compare with baseline cognitive decline?
2. How were cumulative and peak summer temperatures linked to changes in cognitive functioning over a 2-year period?

Our study explores uncharted territory by examining the differential cognitive consequences of these different socio-environmental crises. In doing so, we make a number of notable contributions to the literature and aim to draw sociological attention to an evolving topic: First, we used longitudinal data collected over a period of 15 years among a representative sample of older adults in Germany. This allowed us to compare pandemic and climate impacts on cognitive ageing, using reliable individual baseline rates of cognitive decline for comparison. Second, other than existing studies that focus on one type of exogenous shock or societal crisis, we jointly investigated two crises that are different in nature, using the same individuals and the same time periods, to directly compare their impact potentials. This allowed us to provide a first estimate of potential consequences of different socio-environmental crises in the same population and time window, using comparable measures on different (national and regional) levels, based on a linked macro–micro database.

These explorations not only identify new vulnerabilities of ageing populations during such crises but they also further identify relevant research opportunities and reveal important gaps in research on age(ing), as well as (new and old) social inequalities in times of rapid socio-environmental change. As such, our theoretical considerations and empirical findings are transferrable to other crises, domains, and disciplines, and contribute to wider societal debates about climate change mitigation (Toolan et al. 2022).

2 Theoretical Background and Empirical Evidence: Crises as Drivers of Cognitive Decline?

2.1 Theoretical Models of Brain Ageing and Cognitive Functioning

Theoretical models of brain ageing (Stern 2002) and systematic overview studies and meta-analyses of previous research on single factors (Livingston et al. 2017, 2020) have identified a number of relevant factors for dementia prevention. The importance of these factors has been confirmed in studies investigating their association with levels of cognitive functioning and trajectories of cognitive decline, which are both important predictors for dementia risk (Albert et al. 2011). Many of these factors are of a social nature, for instance educational attainment, employment participation, social contacts, social networks, and participation in social activities such as volunteering (Litwin et al. 2014; 2017). Further research has investigated societal contexts with their cultural norms, educational stratification, and welfare states as contextual factors for promoting cognitive reserve accumulation and buffering cognitive decline in later life (Bertogg and Leist 2023; Bonsang et al. 2017; Leist et al. 2021; Orsholits et al. 2022).

Despite the established idea of lifelong learning leading to protection of cognitive functioning via cognitive reserve accumulation (Stern 2002) and cognitive stimulation (Matyas et al. 2019), few studies have examined the impact of societal crises on cognition in the general population or in later adulthood. Most studies have focused on children's and adolescents' learning losses or forgone learning opportunities due to economic crises (Bisharat et al. 2020; Kershaw et al. 2013), famine (Ampaabeng and Tan 2013), and the recent COVID-19 pandemic (Engzell et al. 2021; Van Lancker and Parolin 2020). Fewer studies have investigated how sudden public health crises, such as the COVID-19 pandemic or increased exposure to hotter temperatures, may impact cognitive health, although both have been linked to lower well-being or life satisfaction (Kobayashi et al. 2022; Li et al. 2022a). Because social environments and social policies can have a cumulative impact on cognition (Rossor and Knapp 2015), we argue that there should be a "cognitive imprint" of socio-environmental crises, as they (rapidly or successively) change access to resources and opportunities for cognitive stimulation. While we agree with Rossor and Knapp (2015) that it is important to study these imprints and their mechanisms across the entire lifespan and for all age groups, in this study we focus on the upper age segment of the population that has been shown to be particularly vulnerable to both crises (Choi et al. 2023; Crivelli et al. 2022) and to rapid cognitive decline (Kravitz et al. 2012; Leist and Mackenbach 2014).

2.2 How Do Crises Impact Cognitive Functioning? Two Pathways

Multiple explanatory mechanisms suggest faster cognitive decline during a crisis as compared to baseline change, including biomedical and social pathways. Concerning the *pandemic, biomedical mechanisms* include health decline due to infection with SARS-CoV-2 virus and its longer-term consequences for physical and mental health (Penninx et al. 2022). Ample studies have documented the relation between worse physical health (Kershaw et al. 2013) and mental health (Caswell et al. 2003) and lower cognitive functioning, as well as its explanatory potential for converting mild cognitive impairment into dementia (Owens et al. 2023). Likewise, depression has been associated with lower cognitive functioning (Kobayashi et al. 2022; Li et al. 2022a). The avoidance of health risks during the COVID-19 pandemic, too, may have cognitive impacts. The closures of nonessential facilities and measures taken to reduce personal contact also reduced older adults' opportunities to access preventive health care and to execute health-promoting behaviours, such as exercise (Pouwels et al. 2021). Regular physical exercise is important to promote brain health, and it benefits cognitive functioning via both improved cardiovascular health and better mental health (Fratiglioni et al. 2004; Ngandu et al. 2015). Preventive health care is important for maintaining cognition via cardiovascular health, sensory functioning (both visual and hearing), and maintaining a healthy weight and blood sugar (Livingston et al. 2017, 2020).

Biomedical pathways are also important to explain the impact of *summer heat* on health. An expert survey among European scholars highlights that climate change may work through risks of extreme hot and cold temperatures, extreme weather events, and tick- and insect-borne viral infections (Mitchell et al. 2024). There might be effects of cumulative heat duration, as well as peak stress. In particular, heat waves have been linked to cardiovascular health risks for older adults. "Heat strokes" are significantly more frequent during hotter summers (Ebi and Hess 2020; Martinez et al. 2011), and strokes are generally associated with worse performance on standard cognitive tests (Einstad et al. 2021; Stolwyk et al. 2021) and increased risk for mild cognitive impairment (Delavaran et al. 2017; Rasquin et al. 2004). Moreover, strokes may damage the brain areas related to language production and might therefore reduce performance on language-based cognitive tests, such as verbal fluency or memory tests. Besides acting via physical health, environmental factors related to summer heat also impact cognitive functioning directly (Zuelsdorff and Limaye 2024) by impacting cognition via air pollution and reduced quality of sleep (see also Khan et al. 2021).

Moreover, important *social factors* for faster cognitive decline during crises can be identified. When the recent pandemic is considered, these include (self-)isolation and the lack of opportunity to participate in cognitively stimulating social activities, such as volunteering and meeting with friends and kin (Brooke and Jackson 2020; Hajek and König 2023). Lack of social participation and isolation have repeatedly been associated with lower cognitive functioning (Almeida et al. 2021; Li et al. 2022b; Litwin et al. 2017). Moreover, fewer social contacts have been associated with worse mental health and less access to support among those with preexisting health care or support needs (for a summary, see Sect. 3).

Although far less research has dealt with the social impacts of climate change, profound "environmental inequalities" (Bolte et al. 2012) can be expected. Following the comprehensive framework of Prina et al. (2024) for studying the impact of climate change on older adults, the social environment, demographic context, and social position matter for vulnerability and resilience to climate hazards and, thus, also for healthy ageing. *Social factors* specifically seem to play a relevant role in the exposure to and reactions to (cumulative and peak) heat: Extreme temperatures (over a longer time span) might lead to changes in lifestyle, such as lower physical activity and lower social participation, which again lead to faster cognitive decline (Yin et al. 2024)—with socially stratified risks, such as faster decline in poorer neighbourhoods (Choi et al. 2023).

To sum up, we expect the following:

H 1 The average cognitive decline between the prepandemic period and the time after the lockdown phase is greater than the average cognitive decline between two prepandemic observations.

H 2 The higher the average or maximum summer temperatures in a given summer, the greater the cognitive decline between the previous and subsequent observations.

3 Previous Research and Research Gaps

3.1 COVID-19 and (Cognitive) Health

While studies concerning the pandemic's physical health consequences have focused on mortality and frailty in older adults (Abedi et al. 2021; Alharbi et al. 2021; Azzolina et al. 2020; Tur-Sinai et al. 2022), mental health problems (Bäuerle et al. 2020; Blix et al. 2021; Serafini et al. 2020) were discussed more generally as consequences of lockdown measures and contact restrictions (Bu et al. 2020; Geirdal et al. 2021; Hajek and König 2023; Van Tilburg et al. 2020). Particularly the latter focused on unequal impacts between age groups (Bruine de Bruin 2021; Horesh et al. 2020; Wilson et al. 2020), genders (Czymara et al. 2020; Horesh et al. 2020; Thorsteinsen et al. 2022), and socioeconomic groups (Drefahl et al. 2020; Mikolai et al. 2020; Sannigrahi et al. 2020). Some studies suggest that older adults may have been less strongly affected by declines in mental health and well-being than children and adolescents (e.g. Fields et al. 2022), but older adults, too, experienced an increase in depression and sleep problems and a reduction in well-being during the COVID-19 pandemic (De Pue et al. 2021; Kivi et al. 2021; Rodrigues et al. 2024; Mendez-Lopez et al. 2022). On the other hand, contact restrictions reduced support potentials for persons with health or social care needs, particularly affecting older adults (Bergmann and Wagner 2021; González-Touya et al. 2021; Wels et al. 2022).

Fewer studies have focused on cognitive health during the COVID-19 pandemic, with the exception of two strands. First, cognitive functioning has decreased among those who had a severe COVID-19 infection (Dale 2022; Ferrucci et al. 2021; Zhao et al. 2023), pointing at lasting cognitive impacts alongside "long Covid". A meta-analysis comparing cognitive developments between older adults with mild cognitive impairments at baseline suggests a sharper rate of cognitive decline among those who were infected with the SARS-CoV-2 virus (Crivelli et al. 2022). Biological explanations relate to oxygen saturation during infection (Ferrucci et al. 2021), inflammation, and brain metabolism (Yesilkaya et al. 2021). Second, studies of both infected and noninfected adults indicate that psychological explanations such as anxiety, loneliness, and isolation account for short-term changes in older adults' cognitive abilities (Kobayashi et al. 2022; Wild et al. 2022). Together, these studies suggest that COVID-19 infection might have an influence on older adults' cognitive functioning via the above-mentioned biomedical and social pathways, largely concurring with theoretical models of brain ageing.

Despite these informative insights, there are research gaps and methodological shortcomings. First, ad hoc surveys fielded during the lockdown were based on convenience samples rather than on representative samples from population registers. Second, many studies relied on online data collection methods, potentially biasing samples towards respondents with above-average cognitive and socioeconomic status. Third, some of these studies lack a prepandemic baseline. Hence, it is difficult to assess how a crisis-related decline deviates from "normal" cognitive decline in a noncrisis situation and how the pandemic's impact may vary for different aspects of cognition.

3.2 Heat and (Cognitive) Health

From a biological point of view, studies involving birds and bumblebees document slower and less complete learning under extremely warm temperatures (Gérard et al. 2022; Soravia et al. 2023). Similarly, a study among firefighters showed immediate short-term impacts of heat exposure on cognitive performance (Thompson et al. 2024). These studies point to heat-related impacts on cognition as a rather universal (biological) mechanism, with potential implication for both short- and longer-term cognitive performance. Although social research on the intersections between (healthy/sustainable) ageing and climate change is still evolving (Gaugler 2024), there is recent evidence for the impacts of heat on cognitive decline and dementia in later life, predominantly from China and the United States (Yin et al. 2024; Choi et al. 2023; Zhou et al. 2023; Hou and Xu 2023), which suggests socially stratified impacts of heat (exposure) on cognitive ageing.

Up to now, few studies in the social sciences have investigated the summer heat impacts on later life health in a European (or German) context (see Bundesregierung 2025). The heat impacts on cognition thus remain to be explored in depth—theoretically as well as empirically.

4 Data and Method

4.1 Data

This study uses data from the Survey of Health, Ageing and Retirement in Europe (SHARE), which is a longitudinal study representative of the population aged 50 years and older. The study has been running since 2004 and has seen an increase in participating countries from 11 (2004) to 28. To date, seven regular panel waves have been fielded in 2004, 2006, 2011, 2013, 2015, 2019–2020, and 2021–2022. All of them contain cognitive tests administered to the entire sample. Interviews conducted in 2009 (wave 3) and wave 2017 (wave 7) were (partly) excluded, as they administered the so-called SHARELIFE interview, which collected retrospective information on childhood circumstances, employment careers, and family biographies among the entire (2009) or a part of the sample (2017; administered to newly added participants).

4.2 Sample Selection: Waves, Country, Participants

Thus, for those participant-years affected by the SHARELIFE data collection, no information on cognitive functioning was collected. The data collection of wave 8, furthermore, is also incomplete with regard to cognitive tests. The fieldwork for wave 8, conducted in 2019–2020, was interrupted by the COVID-19 pandemic (and was later resumed as the SHARE-Corona Survey 1). Wave 8 entails two subsamples, according to the timing of their interviews: one subsample observed before the pandemic (until early March 2020), when the regular panel interview including cognitive testing was still being administered, and one observed after the first lockdown (in summer and fall 2020), consisting of a special questionnaire with pandemic-related questions (the SHARE Corona Survey 1). In our study, we used only data from the first, prepandemic subsample of wave 8. The selection of cases for the analytical sample and the retention between panel waves are documented in Table S.1b in the Online Appendix.

For the analyses, we used data from the Germany country sample, spanning all survey waves from 2004 to 2022. Germany is an interesting case for studying cognitive impacts of the COVID-19 pandemic because it featured two long and strict lockdowns in comparison with its neighbouring countries. The first lockdown was initiated in mid-March 2020 and lasted until June 2020, with a gradual reopening of nonessential facilities during summer. Despite heightened vigilance, contact restrictions, and mask mandates throughout summer and early fall of 2020, incidence numbers and fatalities increased towards the end of 2020, when the German government inflicted the second lockdown. The duration of this second lockdown varied regionally, with containment waivers being tied to averaged local incidence rates over seven days (Bellani et al. 2024; Doblhammer et al. 2021). Concerning summer temperatures and potential heat waves, Germany exhibits high geographical variability, being located between the 47th and 55th latitude in the Northern hemisphere and the 6th and 12th longitude East. The country stretches from the Alps to the Baltic and North Seas, and climate (change) varies significantly between regions, with potentially large differences in exposure to summer temperatures.

We used respondents who were either the main respondent or the respondent's partner, as long as they were at least 50 years old. Both respondents and their partners were considered in a given survey year only if they had a valid interview. This applies to 25,354 person-year observations. We excluded individuals who participated in one wave only (leaving us with $n = 21{,}733$) and respondents who did not participate in two adjacent waves at all (hence, not enabling us to compute change scores of cognitive functioning). The latter left us with $n = 20{,}019$ valid observations (the eligible sample). Finally, we excluded all person-year observations with missing observations on cognitive tests and control variables (described below) using listwise deletion. This left us with $n = 10{,}155$ observations from $n = 4934$ respondents for our analytical sample—about 51% of the eligible sample. The largest drop in case numbers occurred due to a lack of missing valid observations on the dependent variable in two adjacent waves (see Table S. 1b in the Online Appendix for calculations).

4.3 Construction of Dependent Variables

Cognitive functioning was measured with two variables based on standardised tests (Ardila et al. 2006; Ren et al. 2024). Memory functioning was assessed for both short-term and longer-term memory using a ten-word learning list and testing immediate and delayed recall. Both recall measures were added up to a sum score of memory functioning (ranging from 1 to 20). Executive functioning was assessed with a verbal fluency test. Respondents were asked to name as many animals as they could in one minute. The variable ranged from 0 to 100, with a mean of 22.4 animals named (SD = 7.4). For more details on the dependent variables, see Table S. 1 in the Online Appendix.

Both scales are part of the regular Harmonized Cognitive Assessment Protocol (HCAP) used in many population surveys across the globe. They exhibit good psychometric properties in terms of loading on distinct factors, correlation with alternative instruments, and test–retest reliability (see Lachman et al. 2013). Moreover, memory tests are well-suited and easy-to-implement survey instruments both to screen for early dementia symptoms (Dierckx et al. 2010) and to predict dementia development (Fayemiwo et al. 2023).

We computed cognitive change for each of these four variables as the intra-individual change in cognitive functioning between two adjacent panel waves by

Table 1 Crisis measures for COVID-19 and summer heat

Crisis	COVID-19			Summer heat		
	Period dummies	*Waves used to compute average decline*	*N*	*Regional summer temperatures*	*Mean (SD), range*	*Years*
Variable/category	Baseline change rate	Waves 1–2, 4–5, 5–6	6713	Average high summer temperature July and August	17.80 (0.90); 15.4–20.7	2005, 2010, 2012, 2014, 2016, 2018, 2020
	COVID-19	Waves 8–9	1525	Maximum temperature	31.98 (1.89)	
				July and August (average)	27.7–36.02	
	Longer follow-up	Waves 2–4	1372			
Scale	Categorical	$n = 7$ waves	9610	Continuous	–	–
Level	Country	–	–	Federal state (NUTS1)	–	–

COVID-19: Period dummies, categorical variable. No changes were computed between wave 6 (collected in 2017) and wave 7 (collected in 2019), or between wave 7 and wave 8 (collected in 2020), as the cognitive functioning module was only administered to selective respondents in wave 7. For the average time between interviews, see Table S. 3 in the Online Appendix subtracting the level of cognitive functioning at a given time point (t1) from the level of cognitive functioning at the next measurement point (t2). Depending on the survey wave, the average time between waves varies (Table S. 2 in the Online Appendix). Finally, we excluded those cognitive change scores that were obtained from within-person variation between waves 6 and 7 and between waves 7 and 8. The reason for this exclusion was that only about one in four participants in wave 7 did the regular and full panel interview (with cognitive tests). The majority of wave 7 participants were assigned the SHARELIFE interview, as they had joined SHARE only after wave 3, when the first retrospective data collection took place. Hence, that relatively small subsample is likely selective with regard to age, physical health, and, possibly, cognitive abilities also. This may bias the prepandemic comparison group, so it led to the decision to remove the cognitive scores obtained for W6–W7 and W7–W8.

Overall, we computed $n = 9414$ change scores for memory and verbal fluency each. Each change score variable was standardised by dividing the change score by the standard deviation (SD) obtained for the analytical sample in order to make magnitudes comparable across the different measures.

4.4 Identification Strategy: COVID-19 and Heat Exposure

To answer our research questions, we used a longitudinal research design tailored to the comparison of the relevant exposures (COVID-19, heat) measured on different scales (categorical, continuous) and varying nationally, over time, or regionally (Table 1).

Regarding the COVID-19 pandemic, we compared the average cognitive decline during the pandemic period to the average “baseline decline”. The pandemic-related cognitive decline was identified as change in cognitive functioning between the prepandemic period (measured in fall and winter 2019 until early spring 2020) and the period when the COVID-19 containment measures were reduced due to the rollout of vaccines to the general population (measured June–August 2021). In that period, individuals’ cognitive tests were a bit more than two years apart (mean: 25.52, SD: 2.72 months).

The baseline transition rate was computed for each respondent’s two adjacent prepandemic regular panel interviews with a regular follow-up period. In SHARE, this pertains to waves 1 and 2 (average distance in months: 27.8), waves 4 and 5 (average distance in months: 23.5), and waves 5 and 6 (average distance in months: 26.7). Respondents may be included more than once with such a comparison pair (this applies to around 45% of our sample). To put our findings into a broader perspective, we also computed the average decline over a longer follow-up period that results from a change in SHARE’s research design between waves 2 and 4. The longer follow-up period captures those change scores that occurred between waves 2 and 4 (average distance in months: 51.5).

Regarding the impact of climate and heat, we focused on summer temperatures. Data came from the German Weather Service (Deutscher Wetterdienst 2024) and were provided at the regional (NUTS-1) level, which represents the 16 German federal states. As measures, we used both *average* temperatures for the two summer months of July and August because they represent the *cumulative duration of heat* *exposure* (using the average across both months) and the maximum temperatures observed in each of these two months to represent *peak heat stress*.

The average summer temperature in July and August was 18.37 °C, with a standard deviation of 1.28 °C. The minimum was measured in Bremen and Hamburg in 2005 (15.4 °C), while the maximum over the time span and regions considered was recorded in Berlin in 2018 (21.5 °C). Maximum summer temperatures were 35.2 °C (SD 1.8°C) in July and 35.6°C (SD 3.3°C) in August. The lowest maximum temperature was recorded in July 2020 in Thüringen (22.1 °C), and the highest maximum temperature was recorded in August 2018 in Berlin (37.45 °C).

4.5 Analytical Approach

Two sets of statistical models were estimated, each encompassing two steps. First, we estimated the "raw gaps" between the pandemic periods (the first set of models) and cognitive decline, respectively the association between cognitive decline between two survey waves with the average or maximum summer temperatures recorded in the subnational region between these two measurement points (the second set of models). We used random effects models with person-year observations of cognitive changes (change scores) nested in persons (Maas and Hox 2005). These "raw gaps" only adjusted for respondents' age and age squared to allow for curvilinear speed of cognitive decline.

The COVID-19 pandemic was measured with a categorical variable distinguishing the three distinct treatment periods ("prepandemic", "longer follow-up", and "COVID"). The association between summer temperatures and cognitive decline was identified by correlating average change in cognitive functioning between two time points (typically, a 2-year follow-up period), with the average and maximum temperatures measured in the calendar years between two survey waves (see Table 1 for more detail). Thus, the cognitive change between two observations can be attributed to the temperatures in the summer in between, representing a lagged measurement of the exposure. For instance, for a cognitive change occurring between 2004 and 2006, the temperature measure in the summer of 2005 was considered. For longer time gaps (i.e. between waves 2 and 4), we used the temperature of the preceding summer (e.g. in the summer of 2010 for the change computed between 2006 and 2011).

In a second step we adjusted for control variables. These controls comprised respondents' sex (measured as a dichotomous variable), education (measured with three groups representing low, intermediate, and higher education, according to the International Standard Classification of Education), the presence of a partner in the household (measured with a dichotomous variable), the household size (capped at five household members), and a dichotomous variable indicating whether the respondent lived in an urban area. All covariates were measured at t1, referring to the situation at the earlier of the two interviews that were used to compute the change score. We abstained from including covariates as change scores due to potential problems of endogeneity.

Model-specific control variables were introduced for the COVID-19 pandemic and summer temperatures. The models identifying the pandemic's impact on cog-

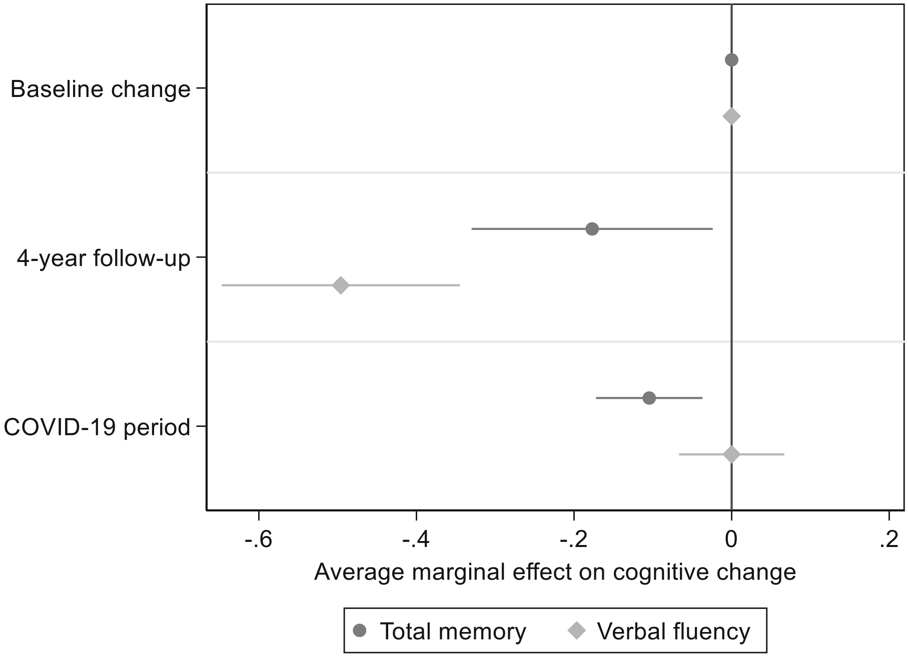

Fig. 1 Cognitive decline during COVID-19 versus baseline prepandemic decline, compared with decline during a longer follow-up period. Random effects panel model of standardised change scores. Unit (x-axis): average marginal effect of period (COVID, longer-follow up) on cognitive decline. Dependent variables (z-standardised): total memory = sum score of immediate and delayed recall, verbal fluency animal naming test. Models control for age, age squared, education, gender, living with spouse or partner, household size, and time since last interview (in months). Coefficients for total memory and verbal fluency: see Table 2

nitive change further included the average number of months between the two interviews used to create each change score to rule out that a larger decline due to COVID-19 may not be due to a longer follow-up period for some respondents.

In the models identifying the association with summer heat, we estimated the magnitude of average and maximum summer temperatures separately adding robust standard errors clustered at a regional level (NUTS-1) to adjust for correlated observations within regions at which summer temperatures were measured. Summer temperatures might work not only in the longer term (i.e. as a lagged effect) but may also impact cognitive functioning during the interview. For that reason, we additionally controlled for the month during which the interview took place. In waves 1 and 4, interviews were spread throughout spring and summer; in waves 5 and 7, interviews took place in the spring months; all other waves were conducted during the winter months.

Table 2 Cognitive impacts of crises—random effects models

	Total memory		Verbal fluency	
	Bivariate	Full model	Bivariate	Full model
COVID-19				
Baseline change (reference)				
Longer follow-up	–0.207**	–0.177*	–0.543***	–0.496***
	(0.078)	(0.078)	(0.077)	(0.077)
COVID	–0.127***	–0.105**	–0.030	0.000
	(0.034)	(0.034)	(0.034)	(0.034)
Controls included	No	Yes	No	Yes
N	9307	9307	9299	9299
Summer heat				
Average summer	–0.039*	–0.028*	–0.037**	–0.026
temperature	(0.015)	(0.014)	(0.014)	(0.014)
Maximum summer	–0.014	–0.009	0.002	0.010
rtemperature	(0.009)	(0.009)	(0.007)	(0.007)
Controls included	No	Yes	No	Yes
N	10,109	10,109	10,102	10,102

* p<0.05
** p<0.01
***p<0.001

Random effects models with change scores as dependent variables; b coefficients and standard errors in parentheses. Robust standard errors clustered at a regional level (NUTS 1). Control variables include age, age squared, gender, education, household size, living with partner or spouse in household, urban area, dementia diagnosis, stroke diagnosis, and time since last interview (for COVID-19). Total memory: summative score of immediate and delayed recall (range: 0–20). Full models present separate estimations for average and maximum summer temperatures.

5 Results

5.1 COVID-19 and Cognition

Figure 1 presents a comparison of the differences in cognitive decline across different periods. The prepandemic transition rate, computed from the average cognitive change between two regular panel waves, served as the baseline and as our reference category in the statistical models. The coefficients are presented in the upper part of Table 2.

Compared to the baseline decline rate, the average change in cognitive functioning during the COVID-19 period (with an average follow-up of 25 months, which was controlled for individually) was only slightly, but significantly, greater (b=–0.105, p=0.003) than the baseline change for the three memory measures between the prepandemic interview and the postpandemic interview. This magnitude corresponds to about 0.35 words remembered from the combined recall tests (1 SD = 3.47 words). The comparison with the bivariate model for memory (b=–0.127, p=0.000), corresponding to about 0.4 words remembered) indicates that the inclusion of the control variables reduces the impact of the COVID-19 period only marginally. No differ-

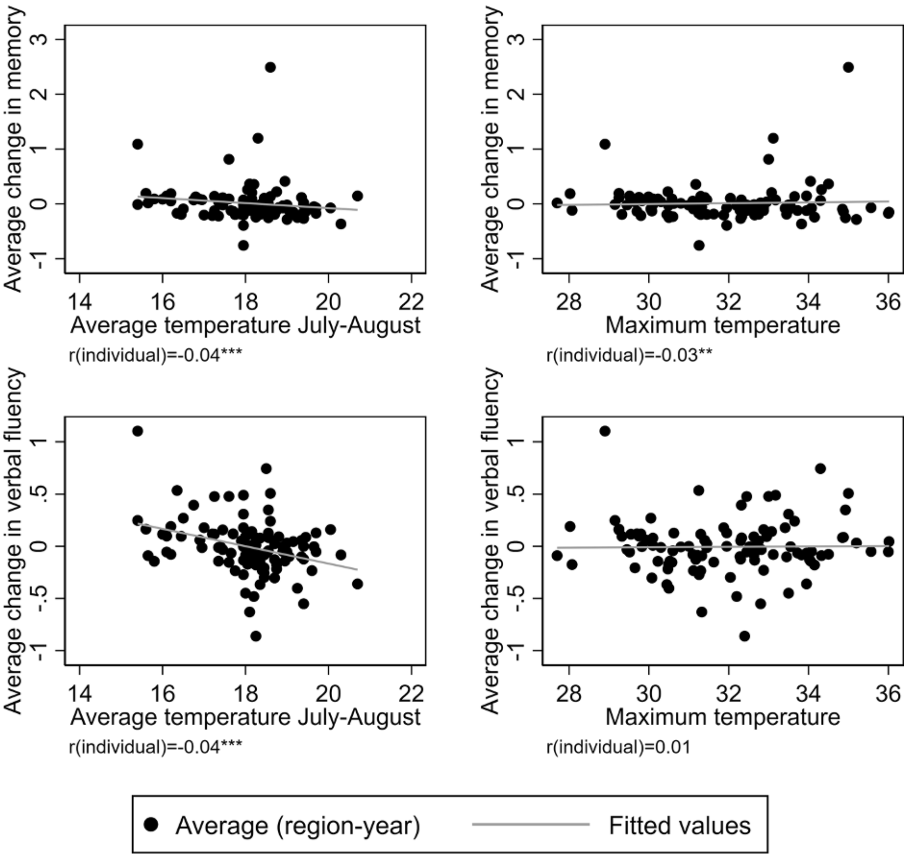

Fig. 2 Correlation between average and maximum regional summer temperatures and cognitive change in total memory and verbal fluency. Temperature data from the Germany Weather Service. Plot: correlation between average temperatures and average cognitive change at an aggregate level (region-years). r (individual): pairwise correlations between individual cognitive change scores and regional temperatures. For a summary of average and maximum temperatures, see Table S. 3 in the Online Appendix

ence between decline in the COVID-19 period as compared to the average (baseline) decline was found for verbal fluency (b=0.000, p=0.992).

For the longer 4-year follow-up period, the memory decline was almost twice as great as during the COVID-19 period and almost 0.2 SD (b=–0.177, p=0.023) greater than the baseline change (the reference). This corresponds to about 0.6 words remembered. For verbal fluency, the average decline was almost half a standard deviation greater than during baseline change (b=–0.496, p=0.000). Such a magnitude corresponds to almost four animals named (1 SD = 7.39 animals).

5.2 Summer Heat and Cognition

While identifying the cognitive impact of COVID-19 was relatively straightforward, assessing the impact of heat waves was more challenging. Progression of climate

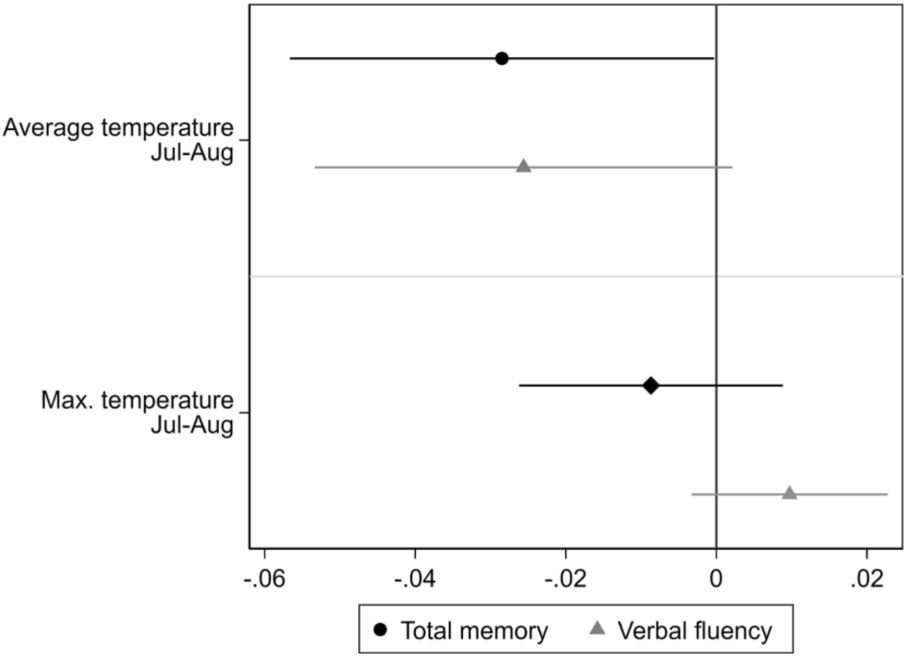

Fig. 3 Associations between average summer and maximum summer temperatures and cognitive change. Random effects panel model of standardised change scores. Unit (x-axis): average marginal effect of summer temperature (in degrees Celsius) on cognitive change. Dependent variables (z-standardised): memory sum score of immediate and delayed recall, verbal fluency animal naming test. Models control for age, age squared, education, gender, living with spouse or partner, and household size. Coefficients: see Table 2.

change is not linear, and even small temperature increases threaten ecosystems around the globe, but the temperature remains seemingly incremental compared to an individual life span. Our study captures climate change over a period of 15 years (with measured summer temperatures between 2005 and 2020). Moreover, observed average and maximum summer temperatures varied considerably in the last two decades, with peaks in certain years (2003, 2007, 2015).

Figure 2 shows the bivariate correlations between average and maximum summer temperatures in the months of July and August and the average cognitive changes in total memory and verbal fluency, aggregated at a regional level. Individual correlation between cognitive change and regional-level temperatures are reported below each figure. Higher average summer temperatures were associated with stronger decline in memory and verbal fluency, while higher maximum temperatures were associated with faster memory decline but were not associated with changes in verbal fluency.

In the next step (Fig. 3), we regressed the average rate of cognitive change between two waves to two indicators of climate impact: the average temperature during the two main summer months (July and August) and the maximum temperatures measured, averaged over these two months.

Overall, memory functioning decreased faster the higher the average summer temperature was in a region (b=–0.039, p=0.012 in the bivariate model; b=–0.028, p=0.049 in the full model). The magnitude of memory decline corresponds to about 0.1 fewer words remembered with each degree Celsius increase in the average summer temperature. Memory change was not significantly associated with maximum temperatures (b=–0.009, p=0.326). Verbal fluency was observed to decline faster the higher the average summer temperatures. The magnitude (b=–0.037, p=0.008 in the bivariate model; b=–0.026, p=0.072 in the multivariate model) corresponds to 0.2 fewer animals named with each degree Celsius increase in the average summer temperature (for the full model). Verbal fluency was not associated with maximum temperatures (b=0.002, p=0.716 in the bivariate model; b=0.010, p=0.142 in the full model).

The magnitude of these coefficients may seem small. Given the fact that cognitive decline starts in midlife, most adults today have several decades of cognitive decline ahead as they enter the second half of life. Each external factor that accelerates such decline increases the "area under the curve" that separates individuals from their potentially achieved levels of cognitive functioning (without exogenous and endogenous threats) and their realised cognitive functioning in later life (Rossor and Knapp 2015). Over time, as temperatures rise and brain ageing progresses, their interaction may lead to a larger reduction of older adults' cognitive capital.

5.3 Robustness Checks

To test for the robustness of our results, we performed a number of sensitivity analyses. First, since our analytical design does not allow identification of causal effects, we re-estimated all our models including additional confounders or mediating pathways, such as physical and mental health and childhood circumstances (Tables S. 4 and S. 5 in the Online Appendix). Health was represented with an index of global activity limitations (GALI; see Van Oyen et al. 2018) and the EURO-D index for depression (see Castro-Costa et al. 2008; Prince et al. 1999). The comparison of these tests with our main results showed no substantial differences for verbal fluency; for memory functioning, the negative coefficient for average summer temperatures becomes insignificant after inclusion of these health items. Further analyses (not shown) including physical and mental health separately found that it was the inclusion of depression reducing both effect size and significance. This suggests that cognitive risks of higher summer temperatures can be explained by mental health risks.

For childhood circumstances, we included the self-reported health up to the age of 15, a self-reported assessment of grades in language and mathematics at the age of 10 relative to classmates, and the number of books in the parental household at that age (all variables derived from SHARELIFE interviews in waves 3 and 7). For verbal fluency, the inclusion of these childhood variables rendered the previously significant effect of the longer follow-up period between waves 2 and 4 insignificant; however, the effect of the COVID-19 period remained unchanged.

Second, we tested for the heterogeneity of these associations across individuals with different sociodemographic and socioeconomic characteristics—because inequality in environmental health risks is well documented—as well as for Germany (Bolte et al. 2023; Heinrich et al. 2000). We did so by including interaction terms with age (measured in groups), gender, educational level, income (in quintiles), and urban versus rural residence (Table S. 6 in the Online Appenidx). These socially stratified analyses suggest that the associations between the COVID-19 treatment and summer temperatures with cognitive decline were largely similar for men and women, for educational and income groups, and for urban and rural inhabitants. However, compared to the youngest age group (50–58 years), the oldest age group (74–100 years) declined more strongly in memory the hotter the average summer temperatures were. When maximum temperatures rose, all higher age groups (59–65, 66–73, 74–100) exhibited faster memory decline than the youngest age group. Verbal fluency also declined faster in the group of those aged 59–65 than in the age group 50–58. Moreover, we found that memory decline over the 4-year period was stronger among the oldest age group (aged 75 years or older) as compared to the youngest age group (aged 50–58 years), but no heterogeneity was found in the impact of the COVID-19 period.

Third, in our models testing the impact of summer heat, we included the interview month as a categorical variable (Table S. 5 in the Online Appendix). The associations between summer temperatures and decline in memory or verbal fluency remained unaffected by this inclusion. However, interview months themselves mattered: Interviews conducted in December had almost 0.1 SD lower memory functioning, whereas interviews conducted in June and July had 0.15–0.2 SD lower verbal fluency. Altogether this strengthens the observation that hotter temperatures in summer may suppress cognitive functioning in older populations, both in the short term (i.e. around the time of the interview, as observed for verbal fluency) and in the longer term (i.e. up to 1 year after interviews were conducted, as observed for memory).

6 Discussion

The aim of this study was to shed light on the imprint of two recent, partly ongoing socio-environmental crises on cognitive health in later life to set a starting point for future (sociological) research on the topic. Studying the impact of the COVID-19 pandemic by assessing the average cognitive decline between the prepandemic and the postvaccine period and comparing it to a prepandemic baseline decline, we found that older adults exhibited a *larger than average decline in memory during the COVID-19 period*, despite a similar length of follow-up period.

Such relative cognitive worsening—when holding constant for age, education, gender, partnership, and living situation—may reflect both presumed mechanisms, a lack of stimulation due to social isolation and reduced social contacts with persons outside one's household (the social pathway); moreover, limited opportunities for exercise and accessing health care (the biological pathway) may be at work. Compared to a longer-term follow-up period of about twice the length, decline in verbal fluency was substantially less during the COVID-19 period and not statistically significant. Our findings stand in contrast to a study among survivors of COVID-19, which found stronger decline for verbal fluency than for memory functioning (Wild et al. 2022)—however, this study measured cognition only approximately 30 days after infection. Our results, based on representative data, suggest that longer-term exposure to the overall pandemic situation may exert a different impact than an individual infection with the SARS-CoV-2 virus. Moreover, the magnitude of the coefficient estimates varied between outcomes: Declines over longer periods were stronger for verbal fluency (0.5 SD) than for memory (at most, 0.2 SD); but declines during the COVID-19 pandemic were greater for memory than for verbal fluency.

Regarding the climate crisis, we found, as expected, that average higher regional temperatures during the peak of the summer in Germany were associated with stronger cognitive declines in the subsequent year across all indicators. Studied bivariately, summer temperatures impacted changes in verbal fluency with a similar magnitude as for memory (about 0.03 SD per degree Celsius). Control variables almost fully confounded the relationship for verbal fluency, but only marginally reduced the association with memory.

Several sensitivity analyses tests suggested that these findings are robust, particularly for verbal fluency. However, the association between summer temperatures and memory was mediated by mental health. Heterogeneity analysis suggested fairly similar associations across various population groups; however, the older age groups exhibited faster memory (but not verbal fluency) decline during hotter summers. Not least, not only medium-term consequences of summer temperatures affected verbal fluency but also hotter temperatures at the time of the interview, as interviews conducted in summer months showed. These additional results suggest that the association between summer temperatures and memory may be more modifiable by demographic characteristics than for verbal fluency. In turn, depending on the outcome, summer heat may have different short- and longer-term impacts, with verbal fluency being more prone to decline during summer months and memory functioning being more likely to decline faster in the longer term.

6.1 Limitations

Our study suffers from a number of limitations that we would like to discuss. First, while we were able to investigate the cognitive impacts of the climate crisis and the COVID-19 pandemic with general, replicable indicators, these indicators lack detail (such as fine-grained local temperatures, consideration of tropical nights, or distinguishing between humid-hot and dry-hot days). Regarding the heat shocks, we focused on summer temperatures. Other climate-related health risks arising from extreme weather events or very low temperatures (see Mitchell et al. 2024) have not been considered in this study. Similarly, the COVID-19 pandemic was operationalised as a period dummy, using a wave dummy approach. Here, too, more detailed information on local infection and incidence rates and cumulative durations of lockdown measures at local levels would be desirable to quantify the pandemic's impact. Incidence rates and stringency of containment measures varied both at regional and local levels (*Kreisebene* or NUTS 3) in Germany; however, the information provided in SHARE does not allow identification of respondents at a lower regional level than NUTS1. Moreover, we were unfortunately not able to simultaneously adjust for possible other contextual influences due to data limitations.

Second, our study provides first hints to cognitive change induced by socio-environmental crises, but our results warrant further investigation. Although some of the theoretical mechanisms we proposed (biomedical and social) can be addressed with the data used in this study, the focus lies in identifying the scope and magnitude of their overall impacts. Future research could focus on examining different pathways explicitly, including the individual contributions of the specific factors (e.g. cardiovascular health, social contacts, sleep quality, mental health, economic strain). For example, we could not ascertain whether the COVID-19 infection itself or related containment measures (or both) led to faster cognitive decline in older adults. Further, using more encompassing measures of cognitive health that span beyond two standardised cognitive tests capturing memory and verbal fluency would be desirable. Due to their unavailability across all SHARE waves (needed to obtain sufficient temporal variation in temperatures and creation of prepandemic baseline changes), other measures were not included in this analysis.

Further, we still have little understanding of the longer-term consequences of exposure to these socio-ecological health risks. Most research on the cognitive impacts of the COVID-19 pandemic has studied their short-term consequences. Our study, too, can only trace its medium-term impacts. With regard to heat waves, cumulative exposure to increased summer temperatures likely produces longer-term impacts, as cardiovascular risks are irreversible. Social risks, on the other hand, can potentially be reversed. Thus, the postulated mechanisms might be studied as potential protective factors that can promote individual resilience.

Fourth, the information we used was based on a longitudinal panel study of the populations aged 50 or older in Europe. Panel studies among older adults may be selective with regard to their participants' health and cognitive abilities (Heid et al. 2021; Matthews et al. 2004). The SHARE interviews are time-consuming, but the in-person interview mode may offset some of these selectivity risks (Lynn 2013), as a recent study on frailty-related attrition documents (Stolz et al. 2018). Future research will have to try to further disentangle possible methodological artifacts (i.e. selection effects, measurement issues, survivor bias) and substantive biological and social mechanisms. Such limitations only underline the need for more research, especially in the social sciences.

Finally, even if the two crises we are studying are similar in many respects in their impact on human lives, they differ in crucial ways: While epidemics and pandemics may have been projected to occur with higher frequency and recurrently (Chin et al., 2020; Marani et al. 2021), presumably with distinct temporal and local restrictions, or rendering particular groups especially vulnerable, climate change is more linear, ubiquitous, and omnipresent, but also less tangible for many even though they are (already) affected (Ogunbode et al. 2019; Sisco 2021). This challenges the interpretation of our findings and their translation into research and policy recommendations.

7 Conclusion and Implications for Policy and Research

Despite its explorative and descriptive nature, our study clearly shows the merits of empirical research at the intersection of ageing and socio-environmental crises, and it highlights the vast research gaps concerning environmental inequalities across the life course and related policy implications for effective mitigation measures in recurring and ongoing crises.

7.1 Policy Implications

Both socio-environmental crises studied, and their health impacts, have implications for policymaking. Despite high public and academic attention paid to the educational, mental health, and inequality consequences of the COVID-19 pandemic, cognitive aspects as (unintended) consequences of lockdown measures among the general and older adult populations have received less attention. The findings presented in this study echo the conceptual idea of a "cognitive footprint" of policies (Rossor and Knapp 2015). We have been able to demonstrate larger memory declines during COVID-19 than during a prepandemic reference period of similar duration. This larger decline is observable in spite of the encompassing pandemic containment measures in Germany (Hale et al. 2021), which strongly prioritised the protection of community-living older adults and aimed at keeping the biomedical risks of infection and mortality at bay. This implies that measures that limit mobility and economic and social activity among the older adult population may reduce their cognitive capital. More stringent containment policies may have reduced biomedical risks, but at the expense of protective social mechanisms.

The access to cognitively protective resources and activities (such as high-skill jobs, volunteering, and educational leisure activities) is highly socially stratified. Hence, policy measures to mitigate (future) public health crises need to be considerate of group-specific and unequal vulnerabilities in the affectedness of the crises and their health impacts. Finally, both climate change and the COVID-19 pandemic seem to threaten older adults disproportionally. Nevertheless, future pandemics or epidemics might pose larger immediate health and mortality threats for younger age groups, or they may affect entire populations equally. Also, when individuals are affected at younger ages, negative health impacts of such crises accumulate and may have long-term impacts on physical, mental, and cognitive capacities, capabilities, and health in later life.

In light of climate change, heat waves and extreme weather events such as floods and droughts and their secondary consequences, such as food insecurity, bushfire, and insect-borne diseases, will become more common around the world, but their impact may be region specific. This study, together with many others (Ebi and Hess 2020; Wettstein et al. 2022), has shown that socio-environmental crises impact older adults' health. In addition to previous studies focusing on risks for cardiovascular health, we have shown that higher summer temperatures are also associated with lower memory and executive cognitive functioning. Policy measures that aim at mitigating the health impacts during acute heat waves will need to be considerate of the particular vulnerability of older adults. Similar to the situation during the COVID-19 pandemic, both informal volunteer activities and civil society organisations have the potential to offer ad hoc neighbourhood support and serve as a bridge between public health interventions (such as heat awareness campaigns) and informal kinship support (such as running errands during hot summer days). Thus, besides emergency plans for unforeseeable extreme weather events, impact mitigation measures should also aim at reducing health burden, strengthening support networks, and promoting individual cognitive growth, considering individual and group-specific vulnerabilities. In an era of multiple and unforeseeable crises, governments will have to prepare tailored measures to protect local and regional populations, as well as vulnerable population subgroups, from the health risks.

7.2 Implications for Sociological Research

Several studies have investigated the short- and longer-term impacts of COVID-19 on cognition in small, nonrepresentative samples across the planet (see, e.g., Almeida et al. 2021; Yesilkaya et al. 2021; Ferrucci et al. 2021), but many studies have focused on the impact of infections with the SARS-CoV-2 virus or have traced cognitive decline among mildly cognitively impaired individuals. Fewer studies have investigated the impacts of climate crises, with a main risk factor being rising temperatures (Abrahamson et al. 2008), on older adults' cognitive health in later life (Choi et al. 2023).

Our study aimed at addressing both research gaps. It provides first important insights into the cognitive impacts of two global socio-environmental crises, which are likely to intensify or recur in the future, as well as in interaction. Based on the first descriptive accounts from a longitudinal survey of a representative sample of older adults, and despite the longer follow-up phase allowing tracing of both temporal and regional variation, more research is needed. First, research gaps pertain to a better understanding of the mechanisms through which these partly differential cognitive impacts come about (see the framework in Prina et al. 2024), trying to identify the social pathways and inequalities from a sociological point of view. Second, future research into the heterogeneities in these associations is needed to identify both vulnerable groups and also factors that promote resilience. Third, vulnerability and resilience also need to be studied from an ecological perspective (Wahl et al. 2012). Comparative research—of countries, regions, and neighbourhoods—will help us understand the interplay of these exogenous shocks with other socio-environmental characteristics. Finally, besides heat waves, other environmental consequences of the climate crises, such as heavy rainfall, food insecurity, and droughts, are associated with cognitive functioning (Pazos et al. 2023). These are more likely to occur in lower- and middle-income countries where the cognitive risks are less studied despite their unparalleled growth (Kenne Malaha et al. 2023; Prince et al. 2008), and study of them contributes to a better understanding of the global cognitive risks of the climate crisis.

The sociological relevance of studying the association between socio-environmental crises—such as the COVID-19 pandemic and heat waves—and health lies in understanding how broader societal events shape individual and collective well-being. Sociological research has emphasised the role of social factors—such as education, income, housing, employment, social relationships, and social networks—and social inequalities in shaping health and well-being. The pandemic's lockdown measures and climate change's environmental shifts have altered these social determinants. Crises often impact vulnerable populations more severely, and this holds true for both COVID-19 and climate change. Studying these associations helps illuminate how systemic inequalities shape health outcomes. Sociological studies of crises and their consequences for individuals, social groups, and societies can be used to inform public health responses and improve preparedness. In informing evidence-based policy responses, social cohesion and resilience can be strengthened and exacerbation of vulnerability mitigated. The literature shows that the impacts of crises on social cohesion can also include positive aspects, for instance by providing opportunities for new forms of civic engagement and welfare solidarity (Rinscheid and Koos 2023; Bertogg and Koos 2021; Koos and Leuffen 2020). In sum, the sociological study of crises and their impact on health deepens our understanding of how social structures, inequalities, and collective experiences influence individual and societal well-being, offering insights for creating more equitable and resilient communities (Guardaro et al. 2022). Population ageing shapes our environment, and our environment shapes the opportunities of ageing well (in place). At this intersection, sociological research is indispensable to inform measures to mitigate (global) social inequalities and enable health and participation until very old age during the turbulent times to come.

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Author Contribution A. Bertogg and M. Brandt conceptualised the article and the arguments. M. Brandt provided an initial literature review. A. Bertogg conceptualised the research design, conducted the data preparation and data analysis, and wrote the first draft. Both A. Bertogg and M. Brandt revised and finalised the manuscript.

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Conflict of interest A. Bertogg and M. Brandt declare that they have no competing interests.

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